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ABSTRACT

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Final Report

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IMAGES AND DEEP STRUCTURES IN RECALL

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Author's Abstract

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In experiment one, nominals with different deep structures showing a recall difference were rated for imagery. No difference was found. In Experiment two, nominals of equivalent deep structure showing no recall difference were rated for imagery. Significant differences were found. In Experiment three, Ss were set to perceive ambiguous nominals with different deep structures and tested for recall. No differences were found. Thus, claims of imagery's importance can be dismissed. However, the failure of Experiment three, raises interesting questions about the psychological status of ambiguity in general.

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Introduction

Recently, a good deal of experimental and theoretical work has been directed at memory for sentences. Several storage mechanisms have been proposed and defended, and both light and heat have been generated. Why all the activity? The answer is fairly obvious. The importance of understanding the mechanism by which a listener remembers a sentence can hardly be overemphasized. Much, if not most, of what we know has been presented to us in sentential form. If one is to use this knowledge one must, at least, store and retrieve the information contained in the sentence, if not the sentence itself. Thus, understanding how sentences are remembered is important, not only to understanding memory, but to understanding the acquisition of knowledge itself.

The process of remembering a sentence can be thought to consist of three stages: placing a representation of the sentence in memory, holding that representation, and retrieving it in recall. Each of these may be subject to investigation; however, the problem that will concern us here is the nature of the memory representation of a sentence.

It is now obvious that language has a complicated hierarchical structure. The sentences of a language can be described at several levels of abstraction. The most concrete level is that of sound. A sentence has a physical manifestation as an acoustical signal, a complex sound wave. A sentence, however, is not heard as noise, but as speech sounds and it is perceived as a series of phonemes. Thus, the phonemic representation is a second level in the structure of language. Clearly though a sentence is not just a string of non-meaningful phonemes. The phonemes are grouped into meaningful units, the morphemes, and this represents another level of structure.

But a sentence is not just a string of words. Sentences have different structures depending upon how their words are grouped together. For example, the sentence "they are sinking ships" has different meanings depending upon whether <u>are sinking</u> is a unit or <u>sinking ships</u> is a unit. Thus, the phrase structure of the sentence defines a fourth level of structure.

There remains a fifth and final level of structural representation. The words of a sentence are related not only by their grouping, but also by logical relations.

For example, the sentence "Sinking ships can be dangerous" cannot be disambiguated by a grouping of words. What is necessary is a specification of the logical relation that exists between sinking and ships. Thus, there must be some underlying level of sentence structure where such relations are made precise and this level is the most abstract of the levels of sentence structure.

It seems reasonable to imagine that any one of these levels (or any combination of them) constitutes the memory representation of a sentence, and that our memory of a sentence can be characterized in the same way that we would characterize that level in a linguistic description. The assumption here is that this is so; our aim is to decide which level is actually contained in memory.

An extensive traditional literature dealing with memory for prose strongly suggests that something beyond the word level is involved in remembering sentences. The earliest study is that of Buhler (1908). Ss attempting introspective accounts of the recall process remembered the meaning of sentences when the exact words were not available. This finding has been repeated in virtually every study of memory for connected discourse done since. McDougall and Smith (1920) found memory for substance better than rote memory. Welborn and English (1937), in a review of the literature, found that most studies indicated scoring for ideas gave higher scores than scoring for rote memorization.

More recently Cofer (1941, 1943) has shown verbatim recall to be more difficult than idea recall on several measures. Epstein (1961) has provided strong evidence that the linguistic structure of a sentence is involved in its recall, and that the syntactic structure of real language adds more than mere sequential constraints. Syntactically structured nonsense materials were better recalled than materials with only high sequential dependencies even though the former involved more material. In a second series (Epstein 1962), he confirmed the original result and with a serial learning task showed that the original effect seems to depend on the series being perceived as a unit-in effect- as a sentence.

Epstein's studies, along with the older literature, suggest that memory for sentences involves a representation of the sentence that is more abstract than a listing of its words, that it involves the abstract syntactic structure of the sentence. Traditional studies of memory for sentences were handicapped by a lack of techniques for describing sentence structures; their conclusions always appeal vaguely to meaning. But tools for the precise description of sentence structure have been provided by current linguistic theory, in particular, the theory of transformational generative grammar.

Transformational grammar (Chomsky, 1957) has as its fundamental notion the idea that a language is based on a system of rules which provide an interpretation for the sentences of the language. A generative grammar consists of a finite set of rules which will mechanically enumerate the infinite set of grammatical sentences of a language and assign them structural descriptions, without appeal to intuition.

Chomsky's (1961) conception of a transformational generated grammar contains three components, a syntactic component, a semantic component, and a phonological component. The syntactic component is the most elementary because it produces the syntactic structures which underly sentences. The syntactic component possesses two subcomponents, a set of phrase structure rules and a set of transformational rules. Figure 1 shows the structure of a transformational grammar.

Figure 1

SYNTACTIC COMPONENT

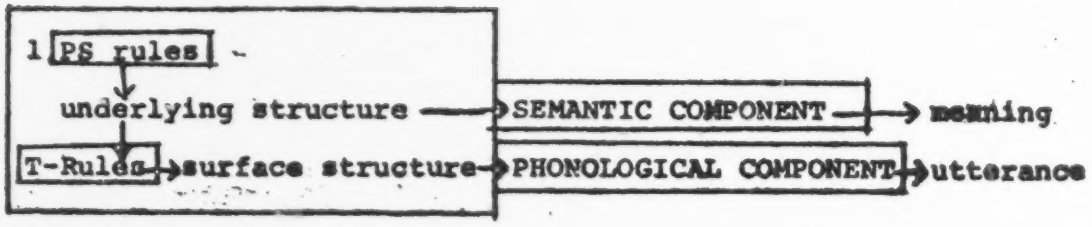


Figure 1

Components of Transformational Generative Grammar

The phrase-structure (PS) rules are rewriting rules of the form A- B+C, where " - " is interpreted as the instruction "rewrite as." These are the rules of formation, by which the basic structures for sentences are formed. For example, a simplified set of PS-rules (taken from Katz and Postal, 1965), might be the following:

S NP+VP
NP John
NP flowers
VP V+NP
V raise+s

These rules may be used to form derivations. Beginning with an initial symbol S, we apply the rules in turn to arrive at a sequence of steps as follows:

S
NP+VP
John +VP
John+V+NP
John+raise+s+NP
John+raise+s+flowers

If we connect successive symbols in the derivation by lines, the result is a phrase-marker of the sort illustrated in Figure 2.

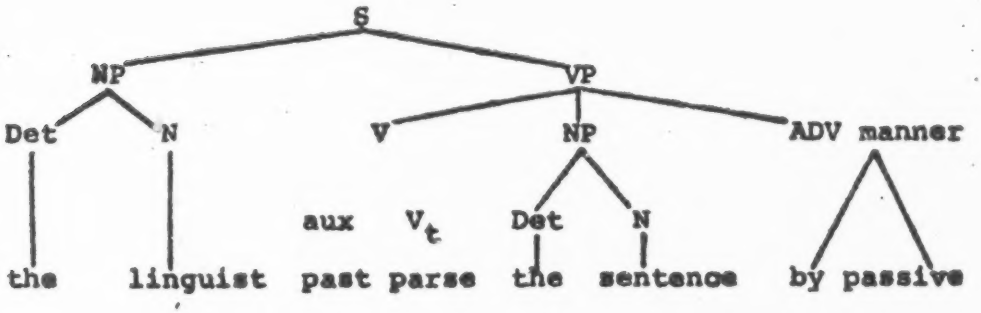


Figure 2

Deep structure underlying, "The sentence was parsed by the linguist."

Every sentence in a language can be represented by such a Phrase-marker (or a sequence of them). This P-marker constitutes the deep structure of the sentence, and it is at this level that the basic grammatical relations are defined (Chomsky, 1965). Defining these relations here eliminates the difficulties found in trying to define them at the sentence level. For example, the grammatical relation Subject of the sentence is defined as a NP immediately dominated by an S node; thus, "linguist" is the subject of the sentence whose deep structure is diagrammed in Figure 2. Similarly, Object of the verb can be defined as a NP immediately dominated by a VP node; thus, "sentence" is the object of the verb in Figure 2.

The transformational rules operate on deep structures --adding, deleting, permuting elements to produce other structures. For example, in English, there are rules for producing passives, questions, and subject and object

nominalizations all from similar deep structures. Application of the transformational rules, ultimately, yields a final derived Phrase-marker, a labelled bracketing of a sentence into a diagram like that of Figure 3.

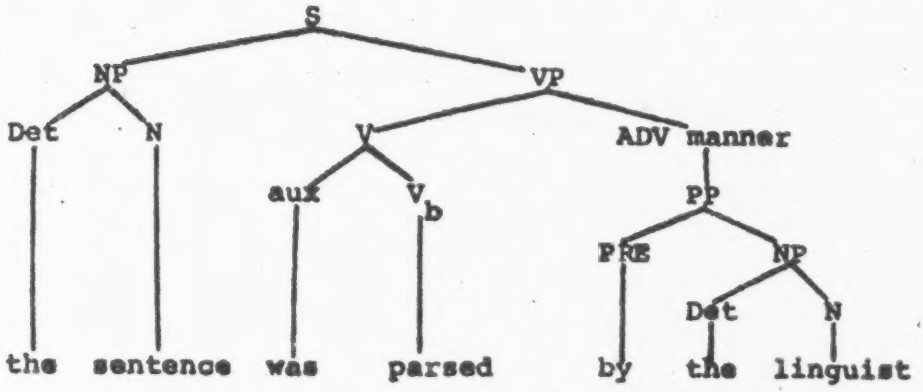


Figure 3

Surface structure of, "The sentence was parsed by the linguist."

This is the surface structure of the sentence, corresponding closely to a description of the sentence by traditional parsing methods.

The diagrams of Figures 2 and 3 are not sentences. They are abstract theoretical entities postulated by linguists to account for the intuition of speakers and are considered intermediate between the sound of a sentence and its meaning. The surface structure (Fig. 3) is converted into a phonological representation (essentially a set of instructions for pronouncing the sentence) by the phonological component. The meaning of the sentence is assigned to the deep structure (Fig. 2) by the semantic component. The surface and deep structures are then related to one another by the transformational rules of the syntactic component.

It should be pointed out emphatically that while Figures 2 and 3 are superficially similar, they represent quite different things. Only at the level of deep structure are the basic grammatical relations, which are necessary to understand the sentence, defined. Notice that while two sentences may have very different surface structure (e.g. The man who shot the moose ate it. The moose was eaten by the man who shot it.), the grammatical relations they express may be identical. Analogously, very

similar surface structures may embody quite different grammatical relations. (The warden protesting the shouting of prisoners ordered it stopped. The warden protesting the hanging of prisoners ordered it stopped.).

Thus, the deep structures of sentences seem to bear the fundamental information load of the sentence. In this respect, they seem a likely candidate as the memory representations of sentences; for it is here that meaning must be defined, there is considerable historical precedent for putting meaning in memory, and the tools given us by transformational grammarians for describing deep structure would seem to make it possible to describe meaning more precisely than before.

In fact, just this was postualted in the seminal psychological studies of grammar by George Miller (1962) and his students. What Miller suggested is that Ss store sentences as a deep structure plus a tag to indicate its ultimate syntactic shape. For example, the sentence, "The book has not been read by the boy," would be encoded as the structure underlying, "The boy has read the book," plus an instruction to perform the negative-passive transformation.

Mehler (1963) found that Ss learning a set of sentences made most of their errors because the S altered the syntactic form of the sentence in recall. He suggested that, "Ss analyze the sentences into a semantic component plus syntactic corrections when they learn them, and that this separation of semantic content from syntactic form is one reason that the general meaning of a message is generally so much easier to recall than its exact wording."

Corroborative evidence was obtained by Clifton, Kurcz, and Jenkins (1965) who showed that Ss are likely to confuse sentences which are closely related transformationally. This would follow from the notion that the sentence is reduced to deep structure in memory.

Sachs (1966a,b) investigated the retention of syntactic and semantic information shortly after comprehension of connected discourse. Ss listened to short, taped passages after which a recognition test sentence was presented. She concluded, "The results indicate that even when the meaning of a sentence is remembered, formal properties that are not necessary for that meaning are forgotten very quickly. When two strings of words have the same meaning, subjects, do not recognize, after a short interval, which of them occurred."

Sachs' results are explicitly interpreted in terms of a theory of language comprehension derived from transformational grammar. "According to this theory, comprehension involves an active, interpretative process. The perceived string of sounds undergoes a syntactic analysis, yielding the 'deep structure' of the sentence. This deep structure is the basis for the semantic interpretation. In the framework of this theory, the experimental results suggest that the original form of the sentence is stored only for the short time necessary for comprehension to occur. Then when a semantic interpretation has been made, the meaning is stored. Thus, the memory of the meaning is not dependent on memory of the original form of the sentence."

Downey and Hakes (1969), in a study of the effect of systematic violation of linguistic rules, have found evidence to indicate that even in the memorization of semi-sentences (utterances which are not well-formed, but still convey meaning), what is stored in memory is deep structure. They conclude "...it is suggested that remembering a sentence (including both the normal sentences and the semi-sentences) involves finding and storing an appropriate underlying P-marker and also storing the lexical items. ..." Thus, once again the deep structure is proposed as the storage mechanism.

Further evidence has been provided by Blumenthal, (1967a,b) who has shown that the ease with which the recall of a sentence is prompted depends upon the relation of the prompt word to the deep structure of the sentence. Words playing a more important role in the deep structure serve as more effective prompts.

All of these studies converge on the conclusion that the deep structure of a sentence is what is stored in memory. That conclusion has been directly challenged, however, by Martin and Roberts (1966). Martin and Roberts propose that the recall of a sentence is determined, not by its deep structure variation, but by its surface structure. The previous research has shown that transformational complexity is related to ease of recall. But as transformations change, so does surface structure. Thus, it is possible that it is surface structure variation, rather than deep structure variation which influences recall.

Martin and Roberts present a theory which would predict just this. They begin by introducing Yngve's (1960) notion of quantifying the structural complexity of a sentence. This metric assigns a number to each word so that the more embedded in the sentence a word is the

higher the number assigned. They give as an example the following: The new club member came early. When a listener hears the first word "the", he expects the rest of the noun phrase and a predicate. Thus, "the" incurs two commitments and is assigned a 2. "New" also arouses expectation for completion of the noun phrase and a predicate and is assigned a 2. Similarly for "club". "Member" completes the noun phrase and leaves only the predicate, but intonation indicates something to follow so "came" is assigned a one. Finally, pitch and stress indicate "early" is the terminal word and it is assigned a zero. Thus, the sentence is characterized by the series of numbers (2, 2, 2, 1, 1, 0) and the sentence has an average depth of 1.33.

A formal procedure for assigning these numbers can be found in Yngve (1960). It consists of drawing a binary phrase-marker tree for each sentence and counting the number of left branches leading to each word.

Martin and Roberts claim these numbers indicate the load imposed on memory in remembering a sentence. They define the mean depth of a sentence as the mean of its Yngve number. They discuss at some length Chomsky's (1957) and Miller's (1962) assertions about memory inputs consisting of a kernel sentence and a transformational tag, and they equate Miller's 1962 position with what they call "transformation grammar theory." They feel recall differences can most parsimoniously be explained in terms of their structural index of mean depth. For experimental support, they had Ss learn a list of 6 sentences in 6 trials. One group's sentences had a mean depth of 1.71, the other 1.29. Examples of their sentences are

1 3 2 1 1 1 0
They were not prepared for rainy weather.--1.29 and

1 4 3 2 1 1 0
Children are not allowed out after dark.--1.71.

They included kernels, passives, negatives, negative-passives, truncated passives, and truncated negative-passives. Each S received a set containing one of each type. Their results showed better recall for the 1.29 sentences. Sentence kind was also significant but not in any consistent fashion. They came to two conclusions. "... structural complexity as indexed by the sentence mean-depth measure is a definitive factor in sentence retention; second, that when sentence complexity and sentence length are controlled, the role of sentence kind in explaining recall behavior becomes marginal."

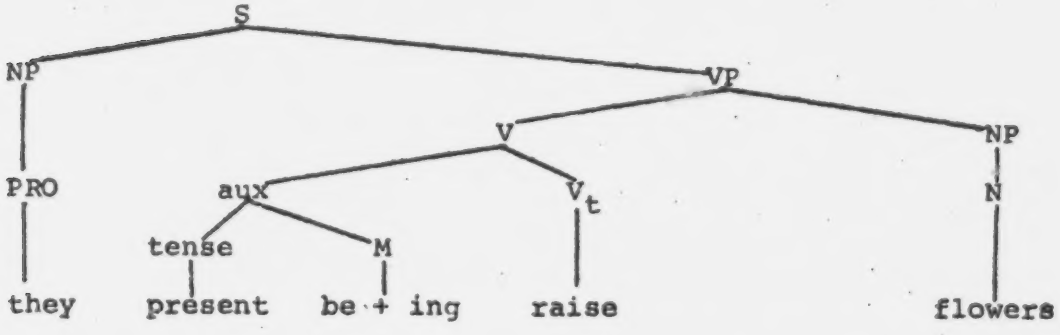
Rohrman (1968) in a series of studies attempted to test these contrasting theoretical views. In Rohrman's first study, 58 Ss were read ten sentences for immediate written recall. Five of the sentences (Type A) were of the form, "They are raising flowers," and five (Type B) were of the form, "They are growling lions." Type A sentences are simpler in deep structure, but more complex in surface structure, than type B. Sentences and associated structures are shown in Figure 4.

Figure 4

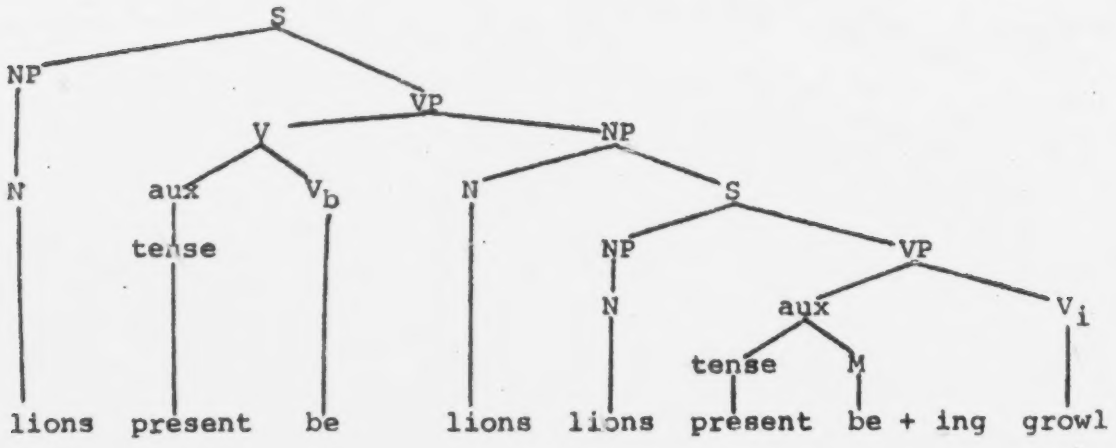
Surface Structures

Type B sentences deep structures are very complex involving recursion and embedding, as can be seen below.

Deep structure underlying "They are raising flowers."



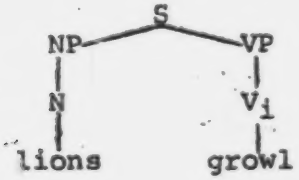
Deep structure underlying "They are growling lions."



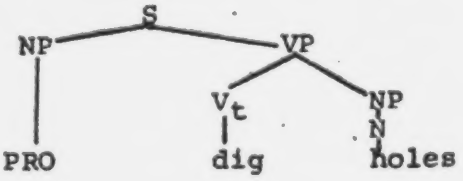
Recall of Type B sentences was significantly greater than recall of Type A. This appears to be strong support for the notion that surface structure is the more important determinant of sentence recall. However, since all sentences were of the form, "They are verb-ing N-pl," it seemed likely that Ss might rather quickly stop attending to the "They are" and merely store the last two words which are nominalizations. Experiment II was conducted to see if the same results obtain with the nominalizations alone. Forty-six Ss were read ten nominalizations of the form, "Raising flowers," and five were subject nominalizations of the form, "Growling lions." Recall of subject nominalizations was significantly greater than that of object nominalizations. Thus, the same result is found with nominalizations or full sentences. The difference in recall of nominalizations can be explained in terms of deep structure. Subject nominalizations have a slightly less complex deep structure with one less node as shown in Figure 5.

Figure 5

Subject nominalizations



Object nominalizations

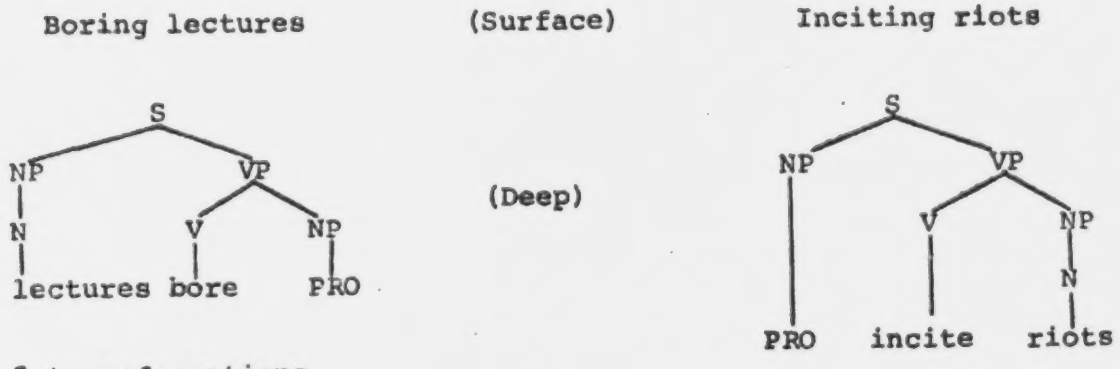


(PRO form represents an indefinite nominal here functioning as subject of the sentence.)

Experiment III extended the findings of Experiment II. Eight groups of 24 Ss were read lists of 20 nominalizations, ten of each type, for immediate written recall. Again subject nominalizations were much better recalled. Experiment IV used 20 Ss, 80 items of each type, and a visual presentation. Results again showed the difference in favor of subject nominalizations to be highly significant.

The difference in recall found in experiments I-IV could be attributed to either of two possibilities. Both nominalizations are transformed, a permutation in the case of subjects and a deletion in the case of objects; and secondly, the object nominalization has an additional node. Experiment V attempted to assess the relative contribution of these two factors. Items were superficially similar to earlier ones, object nominalizations were identical. Subject nominalizations, however, used transitive verbs with objects in the deep structure. Thus, deep structures are equated; but transformational history is different. Items are illustrated in Figure 6.

Figure 6



No difference in recall would indicate deep structure is the relevant variable, while a difference would indicate transformation history is the more important. Thirty-six Ss were shown lists of 14 items for immediate written recall. No differences in recall of the two types of nominalizations were found. Thus, deep structure seems to account for the differences observed in Experiments I-IV. Thus, differences in recall which are not predictable from identical surface structures are predictable from deep structure. The data of Experiments II, III, IV seem to firmly establish the deep structure as the memory representation of a sentence.

This interpretation is compatible with virtually all other current work in the area and the long traditional literature. A problem plaguing earlier work has been the vagueness resulting from using "meaning" as the memory representation which Ss remember, and yet this was obviously what took place. Using the notion of deep structure as discussed here provides a great deal more precision and is both theoretically and practically much more useful than the older semantic terminology.

Experiment V is a start toward more analytic experiments to determine the relevant parameters of the deep structure. The conclusion of this experiment, although tentative, suggests that it is the complexity of the deep structure, as indicated by the number of nodes it containes, which is the major determinant of ease of recall, and not its transformational complexity.

The conclusion has, however, been recently challenged on quite different grounds. Wearing (in press) has suggested that semantic vividness, as measured by imagery ratings is the crucial variable and that syntactic structure is of little importance. Paivio (in preparation) has raised essentially the same point. Wearing, using procedures described by Paivio, Yuille, and Madigan (1968) obtained imagery (I) rating scores on a subset of Rohrman's original items, and also tested them for recall. His recall findings confirmed Rohrman's, but since he found that subject nominalizations (Digging holes) he concluded that semantic vividness as measured by imagery ratings will account for the recall difference without the necessity of invoking underlying syntactic structure. Thus we again have a theoretical dispute.

Settling the dispute is of more concern than mere pedant's pleasure. Transformational grammar is admittedly an extremely complicated theory. However, it has already had considerable impact on school curricula through, for example, the Roberts English series. Since the transformational view has had demonstrated parallels with psychological processes the advantages of early introduction to children are obvious. The major demonstrations of the theory's psychological reality have come from experiments concerned with the memory process. Thus, if these demonstrations are fallacious and if more simple psychological measures will predict recall it would be exceedingly useful to know about them and to conclusively validate those techniques.

Method

Experiment One

In Rohrman's original study there was an experiment (Exp. V) which utilized items of the type, Boring lectures and Inciting riots. These are parallel to items such as Growling lions and Digging holes except the deep structures of the former are comparable in complexity. It has already been demonstrated that there is no recall difference in these items. If Wearing's claim about semantic vividness is correct we should find no difference between these items in their imagery ratings. There items were constructed so that the same verb operated in both the subject and object nominalization, for example, Contributing donors, Contributing funds and Singing choirs, Singing songs. Items are shown in Figure 7.

Figure 7

TYPE A	TYPE B
CHANTING MONKS	CHANTING VESPERS
(monks (chant PRO))	(PRO (chant vespers))

These items are equivalent in deep structure complexity and there is no difference in ease of recall. Fourteen items, half subject and half object, were arranged randomly on a single sheet in two sets so that nominals with the same verb did not occur together. The two sets were distributed to 56 subjects enrolled in introductory psychology. Subjects were instructed to rate each item on how quickly it gave rise to a mental image. The rating scale construction and the instructions to the subjects followed a format desceibed by Paivio, Yuille, and Madigan (1968) and was identical to that used by Wearing. Subjects were run as a group.

Experiment Two

In a recent study Rohrman and Polzella (1968) demonstrated recall differences in subject nominalizations which differed only in deep structure complexity. In previous studies items have been of different grammatical classes, (e.g., subject nominalizations--Growling lions and object nominalization--Digging holes). Here both types of items were subjects and differed only in deep structure, (e.g., Growling lions, Preaching friars). Recall differences have been demonstrated.

28 subject nominalizations used by Rohrman and Polzella (1968) were used. These items (shown in Figure 8) are equivalent in surface structure complexity, but differ in deep structure complexity and have already been shown to differ in relative ease of recall, and the recall difference is predictable on the basis of deep structure.

Figure 8

TYPE A	TYPE B
STRUTTING DANCERS	PREACHING FRIARS
(dancers strut)	(friars (preach PRO))

Twenty-four undergraduates enrolled in introductory psychology at Florida State University served as subjects. Subjects were provided with imagery rating instructions identical to Experiment I. Subjects were again run as a group.

Experiment Three

Finally, to eliminate item differences as completely as possible, we will conduct a recall study using structurally and functionally ambiguous items, after, subjects have been set for a particular perception of syntactic structure.

Items such as, Sinking ships and Burning draftcards, are structurally ambiguous and can function as either subject or object. However, some preliminary work suggests that not all such items are functionally ambiguous. Post-experimental interviews with subjects indicate that items such as "Burning draftcards" is always perceived as an object nominalization. Similarly "Murdering bandits" is always perceived as a subject nominalization.

Approximately 85 structurally ambiguous nominalizations were arranged randomly on 8 x 11 sheets of paper. These were distributed to 42 subjects and subjects were asked to write beneath each item a grammatical sentence in which the item could be used.

Item usage was tabulated as subject, object, or ambiguous usage. Of the 85 items, 21 were functionally ambiguous, having even distributions of object and subjects' uses.

Prior to recall, Ss were set to perceive particular syntactic structures, and imagery ratings were obtained under each of four set conditions.

Group I--Subject set

Subjects were given a definition of a subject nominalization, (e.g., an intransitive verb modifying the following noun--Growling lions). They were then provided with several non-ambiguous examples and then one ambiguous example, again with the definition.

Group II--Object set

Subjects were given a definition of an object nominalization, (e.g., a transitive verb indicating some action performed on the following noun--Shining shoes). They were then provided with non-ambiguous and ambiguous examples.

Group III--Ambiguous set

Ambiguous items were explained to the subjects and it was explained that they could be either subject or object nominalizations. Subjects were then given several ambiguous examples.

Group IV--No set

Subjects were given no set but merely asked to rate a set of nominalizations.

Each group contained 24 subjects, all enrolled in introductory psychology. Evaluation of I ratings showed no significant differences between groups.

Items were then presented for immediate written free recall to two groups of 25 subjects. Subjects were first set for subject or object perception as discussed above.

Procedure

After acquisition of the appropriate set, each subject was run individually in the recall task. Items were displayed tachistoscopically at a 1.5 sec. exposure duration and a 1.0 sec. inter-item interval. Subjects were instructed for immediate written free recall. Each subject was given a different randomization of the item set.

Results

Experiment one

Results were shown in Table 1. As you can see type A items receive higher imagery ratings than type B. A difference score t-test snowed the difference to be highly significant ($t55 = 3.38$, $p < .01$)

Table 1

	TYPE A	TYPE B
EXP. I	1.91	1.65
EXP. II	1.92	1.88

The items are equivalent in deep structure, show no recall difference, yet show significant differences in imagery rating.

Experiment two

Mean imagery ratings are shown in Table 1. A t-test showed the difference to be highly insignificant. Thus, we have a situation where imagery values were equated, but deep structures differ. Recall differences exist where imagery would predict none.

Thus, in both experiments imagery rating leads to an erroneous prediction while deep structure correctly predicts previously observed recall differences. Thus, it appears that for these items imagery is of little value and deep structure is still the crucial variable.

Experiment three

Imagery rating

As previously mentioned differential set produced no significant differences in I rating.

Recall

Subjects were set for perception of subject or object nominals and then tested for recall. No differences were found in amount of material recalled. Thus, either set manipulation failed or some other variable is operative.

Conclusions

In both experiments one and two imagery leads to predictions which are erroneous while deep structure correctly predicts observed recall differences. Thus, it seems that deep structure is still the most powerful variable for describing sentential material and facilitating an understanding of its recall.

Now it seems to me that we ought not to be concerned here solely with determining which of these two variables is the only one operating, but perhaps we might look to see in what kinds of situations one might be expected to be predominant.

Imagery is obviously a powerful variable. Paivio and his colleagues have certainly done considerable service in pointing out its strength and relevant parameters. But too many studies implicate linguistic structures in psychological processing for them to be dismissed by a wave of the pen or the conjuring of the genie of imagery. Although Einstein (Hadamard, 1945) claimed his creative thought processes consisted of non-verbal images I have the suspicion that we lesser mortals may be bound somewhat more by linguistic constraints. And this claim notwithstanding the manipulation of abstract ideas would seem to require linguistic representation. It is difficult to imagine the role mental imagery might play in reading and interpreting something of the nature of Gibbon's "Decline and Fall of the Roman Empire." And this seems to be the flaw in claiming that mental imagery is the answer to all of the cognitive psychologists' problems. It is limited to those concrete situations which can be readily imaged.

A subsidiary claim of Paivio's is that in his studies the noun of the two-word nominals is the most important or "noisey" variable, and that the subject stores only the noun image, and then at retrieval time supplies in a more or less mysterious fashion the appropriate verb. This seems like a somewhat less than optimal strategy. A single image is multiply ambiguous. Without qualification it is open to numerous interpretations. Thus, in Paivio's conception a subject by disregarding the verb robs himself of a very useful memory aid. When a subject is given a linguistic structure I think it very unlikely he will respond to it as if it had no structure.

However, in connection with single items, we recently demonstrated that animate nouns are more readily recalled than inanimate. (Rohrman, 1970; Rohrman, Polzella, and Ackart, 1970). Given the noun sets we used an imagery explanation is probably again helpless. We also found that decisions made about inanimate ones. These data are consistent with an explanation of meaning in terms of redundant semantic features, and again an imagery explanation seems useless.

Finally, there is a flaw in the original study which Paivio overlooks that is of considerable importance to both of us. Notice the items in Figure 5. In subject nominals the verb is intransitive and in object nominals it is transitive. We (Rohrman, 1970) have again recently demonstrated that the transitive verbs in isolation are more difficult to recall than the intransitive. Polzella (1970) has shown that this difference can be explained by using one of the syntactic markers found in Chomsky's Aspects. And again it is very difficult to see how an imagery explanation would handle his findings.

This finding, unfortunately, opens the deep structure model to question. With the items used transitivity and deep structure are inherently confounded, but, it does seem clear that in either case some rather abstract theoretical linguistic unit is playing a crucial role in recall. The issue of lexical complexity and its interaction with syntactic complexity is far from settled. The deep structure model will undoubtedly need to be modified to include new syntactic and semantic units, as these become understood, but for the present we feel that the current data plus earlier findings indicate that a deep structure notion is still the most generally useful and preferable model. While imagery may have been confounded with syntactic complexity in certain sets of items, it is not crucial to a general explanation of linguistic memory.

Current educational practice, particularly English curricula, based on transformational generative linguistic theory is soundly based so far as the psychological reality of grammatical theory is currently understood.

Future Research

The failure of experiment three raises questions about the interpretation of ambiguous verbal materials. A fair amount of psycholinguistic investigation has been directed at this topic, but it has not looked at attempts to manipulate the comprehension of the items themselves. The role of transitive verbs is particularly crucial for materials of this sort. Hopefully, a comprehensive research program focusing on this problem will be directed at this problem by the author in the near future.

Utilization of Research Findings

Data discussed were presented at the annual meeting of the Midwestern Psychological Association, Detroit, May, 1971. They will be published in an appropriate journal as soon as they can be readied for publication.

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Appendix A

IMAGES, DEEP STRUCTURES AND RECALL

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Paper presented at the Midwestern Psychological Association meeting, Detroit, May, 1971.

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Images, Deep Structures and Recall

Nicholas L. Rohrman

Florida State University

Beginning with Miller's (1962) paper, "Some Psychological Studies of Grammar," a vast number of experiments have demonstrated the psychological utility and reality of transformational linguistic theory. Linguistic variables of many types, several of great subtlety and abstractness, have been consistently shown to be deeply involved in the psychological processes used in the comprehension and use of language.

Perhaps the most useful of Miller's several suggestions concerned the memory representation of sentences. There is an enormous traditional literature dealing with memory for sentences, and for approximately 80 years psychologists had been aware that when someone remembers a sentence he remembers its meaning. However, we had no way of characterizing this meaning and this kind of semantic terminology was essentially useless. Miller's idea, although phrased in the terminology of kernel sentences and syntactic tags, was that the deep structure of a sentence serves as its representation in memory. Jacques Mehler (1963) provided some of the first data to support the idea.

This suggestion was not received with universal acclaim, and Martin and Roberts (1966) suggested that considerations of the complexity of the surface of a sentence would be

sufficient to predict the observed recall differences. Following this in a series of experiments I (Rohrman, 1968) using items of the type illustrated in Figure 1, attempted to oppose the predictions derived from surface and deep structures and concluded that the deep structure of sentences must be considered in any discussion of memory representation.

This notion has been a very productive one and deep structures seem to be at the heart of our processing of language.

However, the conception as it applied to memory, has again been challenged, and dismissed. This time not on the grounds that other levels of linguistic representation are superior, but on the grounds of irrelevance. Two recent studies have claimed that the original nominalization study is confounded by imagery. The first, that of Wearing (1971), claims that the type A nominalizations in Figure 1 are higher in "semantic vividness" than the type B, and therefore the structural notion defended by Martin and Roberts is still viable. Wearing apparently does not want to argue that semantic vividness is the only crucial variable involved. The second study however, does. Paivio (1971) argues for imagery only, claiming that it will account for the previous data, and that all notions derived from transformational linguistic theory are erroneous.

However, both studies have methodological points that I feel might be handled better and since I have some interest in the area I decided to conduct my own imagery rating study.

In Experiment I, 28 subject nominalizations used by Rohrman and Polzella (1968) were used. These items (shown in Figure 2) are equivalent in surface structure complexity, but differ in deep structure complexity and have already been shown to differ in relative ease of recall, and the recall difference is predictable on the basis of deep structure. Incidentally throughout, the recall differences are not in dispute. They have been replicated in at least three laboratories and seem quite stable and reliable. What is debatable is the theoretical mechanism responsible for the recall difference. These items were arranged randomly on two sheets, each item above a four-point rating scale. Subjects were instructed to rate each item on how quickly it gave rise to a mental image. The rating scale construction and the instructions to the subjects followed a format described by Paivio, Yuille, and Madigan (1968) and was identical to that used by Wearing. Twenty-four undergraduates enrolled in introductory psychology at Florida State University served as subjects. Subjects were run as a group.

Mean imagery ratings are shown in Table 1 of the handout. A t-test showed the difference to be highly insignificant. Thus, we have a situation where imagery values were equated, but deep structures differ. Recall differences exist where imagery would predict none.

In Experiment II we attempted to reverse this situation. Fourteen subject and 14 object nominalizations used by Rohrman (1968, Exp. V) were used. Items are shown in Figure 3 of the handout. These items were constructed so that the same verb was used with different nouns to give the complete set (e.g., chanting monks, chanting vespers). These items are equivalent in deep structure complexity and there is no difference in ease of recall. Fourteen items half subject and half object, were arranged randomly on a single sheet in two sets so that nominals with the same verb did not occur together. The two sets were distributed to 56 subjects enrolled in introductory psychology with imagery rating instructions identical to Experiment I. Subjects were again run as a group.

Results were shown in Table 1 of the handout. As you can see type A items receive higher imagery ratings than type B. A difference score t-test showed the difference to be highly significant. ($t_{55} = 3.38$, $p < .01$.). Thus, we do find the reverse of Experiment I. The items are equivalent in deep structure, show no recall difference, yet show significant differences in imagery rating. In both experiments imagery rating leads to an erroneous prediction while deep structure correctly predicts previously observed recall differences. Thus, it appears that for these items imagery is of little value and deep structure is still the crucial variable.

Now it seems to me that we ought not to be concerned here solely with determining which of these two variables is the only one operating, but perhaps we might look to see in what kinds of situations one might be expected to be predominant.

Imagery is obviously a powerful variable. Paivio and his colleagues have certainly done considerable service in pointing out its strength and relevant parameters. But too many studies implicate linguistic structures in psychological processing for them to be dismissed by a wave of the pen or the conjuring of the genie of imagery. Although Einstein (Hadamard, 1945) claimed his creative thought processes consisted of non-verbal images, I have the suspicion that we lesser mortals may be bound somewhat more by linguistic constraints. And this claim nonwithstanding the manipulation of abstract ideas would seem to require linguistic representation. It is difficult to imagine the role mental imagery might play in reading and interpreting something of the nature of Gibbon's "Decline and Fall of the Roman Empire." And this seems to be the flaw in claiming that mental imagery is the answer to all of the cognitive psychologists' problems. It is limited to those concrete situations which can be readily imaged.

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However, in connection with single items, we recently demonstrated that animate nouns are more readily recalled than inanimate. (Rohrman, 1970; Rohrman, Polzella, and Ackart, 1970). Given the noun sets we used an imagery explanation is probably again helpless. We also found that decisions made about the meaning of animate items are faster than comparable decisions made about inanimate ones. These data are consistent with an explanation of meaning in terms of redundant semantic features, and again an imagery explanation seems useless.

Finally, there is a flaw in my original study which Paivio overlooks that is of considerable importance to both of us. Notice the items in Figure 1. In type A the verb is intransitive and in type B it is transitive. We (Rohrman, 1970) have again recently demonstrated that the transitive verbs in isolation are more difficult to recall than the intransitive. Don Polzella (1970) has shown that this difference can be explained by using one of the syntactic

markers found in Chomsky's Aspects. And again it is very difficult to see how an imagery explanation would handle his findings.

This finding, unfortunately, opens the deep structure model to question. With the items used transitivity and deep structure are inherently confounded, but, it does seem clear that in either case some rather abstract theoretical linguistic unit is playing a crucial role in recall. The issue of lexical complexity and its interaction with syntactic complexity is far from settled. The deep structure model will undoubtedly need to be modified to include new syntactic and semantic units, as these become understood, but for the present we feel that the current data plus earlier findings indicate that a deep structure notion is still the most generally useful and preferable model. While imagery may have been confounded with syntactic complexity in certain sets of items it is not crucial to a general explanation of linguistic memory.

HANDOUT

Figure 1

TYPE A	TYPE B
GROWLING LIONS	DIGGING HOLES
(lions growl)	(PRO (dig holes))

Figure 2

TYPE A	TYPE B
STRUTTING DANCERS	PREACHING FRIARS
(dancers strut)	(friars (preach PRO))

Imagery equated, deep structures non-equivalent, recall differences

Figure 3

TYPE A	TYPE B
CHANTING MONKS	CHANTING VESPERS
(monks (chant PRO))	(PRO (chant vespers))

Deep structures equivalent, imagery non-equivalent, no recall differences

Table 1

	TYPE A	TYPE B
EXP. I	1.92	1.88
EXP. II	1.91	1.65